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A LOOK AT THE FEDERAL SECTOR .

by

10 David Richard Timmons

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An important resource in the search for solutions to serious issues confronting the United States is the science and technology which result from Federally funded research and development. To obtain the optimum return on this significant investment requires that the resultant technology be adapted for secondary utilization and/or be transferred to primary and secondary users. This paper describes the magnitude and scope of

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Technology Transfer -

a look at the Federal Sector

by

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requirements for the degree of

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ABSTRACT

An important resource in the search for solutions to serious issues confronting the United States is the science and technology which result from Federally funded research and development. To obtain the optimum return on this significant investment requires that the resultant technology be adapted for secondary utilization and/or be transferred to primary and secondary users. This paper describes the magnitude and scope of Federally sponsored research and development and describes the major Federal technology transfer efforts. While present technology transfer efforts, mostly passive, are necessary, the need for more active methods is pointed out. The Federal government is seeking ways to improve its technology transfer effort. General agreement on the following actions appears to exist: stronger support by Federal research and development management, and increased commitment of personnel and funding to the Federal technology transfer effort.

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I. INTRODUCTION

A. OBJECTIVES

There are two objectives to this paper. The first is to provide the reader with an understanding of the magnitude and scope of the Federally funded research and development effort. The second, and more important objective, is to develop within the reader an appreciation for and an understanding of the Federal government's efforts to transfer the technology resulting from this research into use by private and other public sectors, including:

1. technology transfer objectives;
2. resultant benefits;
3. methodologies of the major efforts;
4. how public and private organizations and private citizens interact with these efforts; and
5. possible changes in these efforts.

B. BACKGROUND

In its relatively short existence, the United States of America has become the leading industrial nation in the world and the leader of the free world countries. However, the United States faces a multitude of social and economic problems and challenges that require immediate solutions if its people are to continue to enjoy their present standard of living, and the nation is to retain its position as a major world power.

The energy crisis, inflation, unemployment, pollution, urban decay, housing, and many other national concerns, which are equally as meaningful in keeping this nation strong, face Federal, state and local governments. The seriousness of these problems is exemplified by the rapidly increasing foreign trade deficit. This deficit is largely the result of foreign oil payments which are necessary to meet the nation's demand for energy [Ref. 1, p. 1]. While seeking solutions to such problems, progress must continue to be made in areas such as space exploration, oceanography, meeting the nation's health needs, and in the maintenance of a modern, strong defense force. While this country is blessed with many resources, they are not unlimited. The numerous demands for resources mandate that the benefits realized from them be maximized.

The resources of Federal, state, and local governments, private industry, universities and nonprofit organizations must be efficiently and effectively utilized in meeting the nation's needs. The majority of these needs may be met "through the proper utilization of existing and developing science and technology resources." [Ref. 2, p. 1] The National Science and Technology Policy, Organization, and Priorities Act of 1976 states the following:

> "the scientific and technological capabilities of the United States, when properly fostered, applied, and directed, can effectively assist in improving the quality of life, in anticipating and resolving critical and emerging international, national, and local problems, in strengthening the Nation's international economic position, and in furthering its foreign policy objectives." [Ref. 3, p. 1]

Science and technology result from research and development. Today, as in past years, huge sums of money are being spent on research and development in the United States. The Federal government spends more money on research and development than all other organizations combined, and has been doing so for many years. "Research and development is conducted throughout the Federal government. Most agencies and departments support research and development to further advances in those fields of science and technology which are related to their mission." [Ref. 4, p. 1]

This large expenditure of Federal government funds over the years has produced a vast amount of products, processes, and knowledge. These have often advanced the state of the art and/or resulted in patents being issued. The results of this research and development effort have cut across almost the entire spectrum of science and technology.

The majority of Federal research and development funds are used to contract research and development work out to nongovernment entities; private industry, universities, and nonprofit organizations. However, the largest single recipient of Federal research and development funds are the Federal laboratories and research centers [Ref. 5]. The Federal holdings in facilities and equipment for conducting research and development are immense. The expertise that exists in the Federal laboratories is a tremendous national resource. Federal laboratories and their personnel represent a vast variety of specialized, in-place, scientific and engineering competence and experience [Ref. 6, p. iii].

One of the objectives of technology transfer in the Federal government is to optimize the benefits from Federal funds expended on research and development by taking the knowledge, facilities, and capabilities developed and transferring them to fulfill actual or potential public or private needs. By so doing, a greater return on the taxpayer's investment in science and technology is achieved through more effective primary and secondary use of Federally funded research and development results and capabilities. [Ref. 2, pp. 1,2].

The expression "technology transfer" means different things to different people. The teacher in the classroom may think of the teacher-pupil relationship as technology transfer. The industrialist may think of carefully illustrated and printed service manuals as technology transfer. While there is not one universally accepted definition of technology transfer, most people, if not all, who are familiar with the general meaning would agree that technology transfer is inherently good; when it occurs there is at least some small economic or social benefit [Ref. 7, p. v].

For the purpose of this paper, technology transfer is considered to be the process which:

> "encompasses the collection, documentation, and dissemination of scientific and technical information, including data on the performance and cost of using the technology; the transformation of research and technology into processes, products, and services that can be applied to public or private needs; and the secondary application of research or technology developed for a particular mission that fills the needs in another environment." [Ref. 8, p. v]

After having presented this somewhat long definition, a more succinct definition of "technology transfer may simply be stimulating or helping someone other than the research supporter to use the research results." [Ref. 9, p. 11]

This paper will not concern itself with an analysis and evaluation of the various methodologies of technology transfer, that would be a study in itself. However, there are a few things about technology transfer methodology on which there is widespread agreement:

1. Technology transfer is a people thing [Ref. 10].

   > "The mere availability of information does not cause its transfer or use. Printed materials alone, even expertly prepared, cannot stimulate interpersonal relations, define a problem, answer related questions, involve consulting authorities, provide follow-through on problems or relate to other agencies." [Ref. 4, p. 14]

   It is in the discussion between knowledgeable people that the compatibility between capability and opportunity (need) has been, and will continue to be, recognized [Ref. 11, p. 6].

2. While there must be both "technology push" and "requirements pull" (sometimes called supply and demand) to effect technology transfer, the more important of the two to the success of the technology transfer process is "requirements pull." [Ref. 4, p. 17] "Technology push" is what is technologically feasible and the eagerness of the research and development community to do it. "Requirements pull" are the problems that need to be solved [Ref. 12, p. 2-13]. "Requirements

pull" necessitates communication and coordination between the technology supplier and the potential users about needs and problems from the initial stages of research and development. This approach has been much more successful in matching available technology with existing problems than a pure "technology push" approach [Ref. 4, p. 5].

Appendix A is taken from a 1974 report by the Committee on Technology Transfer and Utilization (COTTU) entitled Technology Transfer and Utilization. It lists a number of dynamic steps that occur in varying degrees in the technology and utilization process. It should be noted that the broad definition of technology transfer used in this paper includes both technology transfer and utilization as defined in the above report. The steps listed are very helpful when thinking about the technology transfer process, although some of the items mentioned apply to private industry and not to a government technology transfer effort.

Both in the private sector and the public sector, the problem of technology transfer involves a linking of the technologies at one extreme with needs at the other by means of a complex "brokerage process." At the technology end, there is a body of knowledge which results from research and development for primary mission purposes, but nonetheless, has numerous potential secondary or horizontal applications. At the other end, there is a set of societal needs that will utilize some combination of the technologies. Once these needs are defined, the brokerage process serves as the catalyst to help match the needs to the technologies [Ref. 13, p. 9].

II. FEDERALLY FUNDED RESEARCH AND DEVELOPMENT

A. THE MAGNITUDE OF THE FEDERAL RESEARCH AND DEVELOPMENT EFFORT

1. Funding

In fiscal year 1977 (FY77) scientific research and development accounted for some $40 billion worth of goods and services in the United States. Twenty-five billion of this enormous enterprise was paid for by the Federal government, while industry, collectively, spent about $15 billion [Ref. 9, p. 8]. In fiscal year 1978 it is estimated that the Federal government will spend $26 billion on research and development, or about 65 percent of all such money spent in the United States. Admiral Hyman G. Rickover testified before a Senate subcommittee that this percentage may be as high as 85 percent due to private industries' practice of labeling as research "items which are not research at all, such as cosmetic improvements in the appearance of items." [Ref. 14, p. 8]

Figure 1 depicts the Federal spending on research and development from fiscal year 1940 to the present. The heightened level of spending in the 1960's was the result of research and development in support of:

1. The National Aeronautics and Space Administration (NASA) programs, in particular the program to put a man on the moon i.e., the Apollo program.

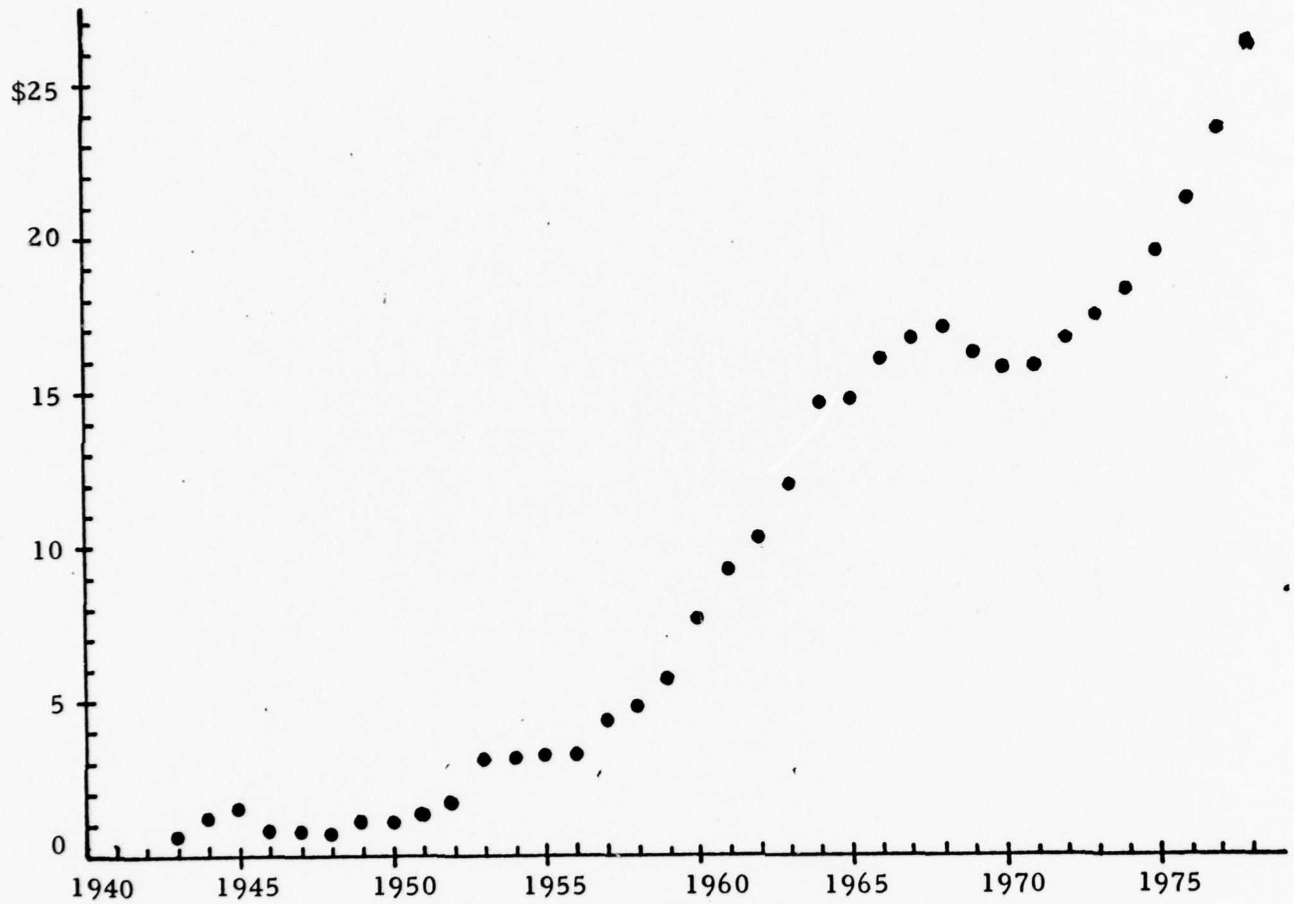

Figure 1
Federal Research and Development Outlays by Fiscal Year (billions of dollars)
[Ref. 15, p. 4; Ref. 16, p. 437; Ref. 17, p. 3]

2. The Vietnam war effort.

Table I breaks fiscal year 1978 Federal research and development obligations into 15 functional categories. These categories "were chosen to make visible the chief objectives reflected by research and development programs in the 1978 budget." Each program was placed only under the function that embraces its primary purpose, although programs may have had secondary purposes [Ref. 17, p. 1].

TABLE I

Federal Research and Development Obligations by Function,
Fiscal Year 1978
(estimated, millions of dollars)

Function	Obligation	% of Total
National Defense	12,907	49.0
Space	3,140	11.9
Energy development and conversion	2,798	10.6
Health	2,683	10.2
Environment	1,098	4.2
Science and technology base	1,060	4.0
Transportation and communications	805	3.1
Natural resources	610	2.3
Food, fiber, and other agricultural products	488	1.8
Education	269	1.0
Income security and social services	148	0.6
Area and community development, housing and public services	99	0.4
Economic growth and productivity	97	0.4
International cooperation and development	71	0.3
Crime prevention and control	44	0.2
Total	26,317	100.0

[Ref. 17, p. 3]

Appendix B lists the outlay of Federal research and development funds by agency and subdivision for fiscal year 1977. Almost all Federal government agencies engage in research and development. Although the missions of these agencies are very divergent, their need to conduct research and development, in varying degrees, is common. In 1976 there were 91 Federal agencies with research and development programs. [Ref. 15, p. viii].

The present level of spending on Federal research and development may increase markedly in the coming years, over and above the increase due to inflation. Among the reasons why are the following:

1. It is expected that Federal expenditures on research and development to develop new sources of energy will rise rapidly. Between 1974 and 1978 Federal research and development funding for energy increased more than four and one half times [Ref. 17, p. 2]. As an example, the Federal government has proposed a research budget for electrics in fiscal year 1979 of $39 million, up from an annual budget of $200,000 in the early 1970's. The primary objective of this research is to develop low-cost, lightweight, long-range batteries to power electric automobiles [Ref. 18, p. 53].
2. As other natural resources, particularly metals such as copper and tin, become depleted there may be greater

need for Federal expenditures for research to find substitute materials and new, more economical processing methods [Ref. 19, p. 3].

3. The problems facing the nation tomorrow will amost certainly be more complex than the ones of today. More complex problems require more complex solutions. In almost all cases, the more complex a solution is, be it a piece of equipment or a process, the more expensive it is.

It should be pointed out that no Federal budget for research and development exists, as such. No one decision determines what the research and development total funding will be. Rather, the final total for research and development in any Federal budget is the result of innumerable decisions regarding the programs of separate organizations. "Decisions on the size and nature of research and development programs are based on the way they support agency missions and <u>not</u> on the way research and development functional elements relate to one another within the total budget." (underlining added for emphasis) [Ref. 15, p. ix]

2. <u>Facilities and Personnel</u>

The Federal facilities for conducting research and development are located in over 500 laboratories and research centers and hundreds of technical field stations located in all 50 states, the District of Columbia, Canal Zone, Puerto Rico, Virgin Islands, Antarctica, and a number of foreign countries. A 1969 report identified 723 such

research and development installations and lists them by state, outlying area and foreign countries. Today such activities employ about 120,000 scientists and engineers, which is approximately 23 percent of the total number of scientists and engineers engaged in research and development in the United States [Ref. 4, p. 33; Ref. 20, pp. ix, 1027-32; Ref. 21, p. 1]. The Federal laboratories and research centers are dedicated to and administrated by different government agencies which are charged variously with missions such as space exploration, national defense, energy, health, agriculture, natural resources and transportation. These agencies receive about 35 percent of the Federal government's research and development budget. The remaining 65 percent is used to contract out research and development work to universities, private industry and non-profit organizations [Ref. 5].

There are three major categories of Federal laboratories:

1. Special-mission laboratories: have missions which often require high technology, but they have no inherent requirement to work with state or local governments or private industry (Department of Defense and National Aeronautics and Space Administration make up the vast majority of these).
2. Civil-mission laboratories: have an inherent need to work closely with state, local, and other Federal government units, and in some cases the private sector, in order to implement their programs (examples: Department of Transportation; Department of Commerce; Environmental

Protection Agency; Department of Health, Education and Welfare; and Department of Agriculture). [Ref. 6, pp. 3, 4; Ref. 9, pp. 107-8]

3. Federally Funded Research and Development Centers (FFDRC's) are research and development performing or managing organizations exclusively or substantially financed by *one or more* Federal agency and administered for them by industrial firms, universities, or nonprofit institutions. In 1977 there were 39 FFRDC's sponsored by six Federal agencies [Ref. 15, p. 13].

   The FFRDC's sponsoring agency has direct access to the center's resources. Additionally, the sponsor typically approves proposed undertakings of major or significant research and development activities of the FFRDC for other organizations [Ref. 20, p. ix].

It is important to remember that the Federal laboratories and research centers exist in a balkanized state, accountable to a variety of Federal agencies and subagencies (see Appendix B). There is no integrating management system, they are a fragmented lot. [Ref. 6, p. 8]

B. THE SCOPE OF THE FEDERAL RESEARCH AND DEVELOPMENT EFFORT

The preceding section attempted to give the reader a feel for the amount of assets that are dedicated to the Federal research and development effort. "Shocked," "amazed," or "flabbergasted" would not be

inappropriate words to describe the usual reaction of people when they are made aware of the magnitude of this effort. Their next reaction might be to ask the following question, "What is it all used for?" This section will try to answer that question by describing for the reader the scope of the Federal research and development effort.

The Federal research and development assets are used for basic research, applied research and development. Basic research is directed toward an increase of knowledge or understanding in science by gaining a fuller knowledge or understanding of the subject under study. Applied research is directed toward the practical application of scientific knowledge or understanding for the purpose of meeting a recognized need. Development is the systematic use of scientific knowledge and understanding, directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes. Development excludes quality control, routine product testing, and production [Ref. 15, p. 54]. In 1977 the Federal research and development obligations were divided between these three disciplines approximately as follows [Ref. 15, pp. vi, 4]:

Basic research	2.7 billion (11 percent)
Applied research	5.7 billion (23 percent)
Development	16.3 billion (66 percent)

Appendix C lists some of the areas in which Federally funded basic research, applied research and/or development are carried out. This

list is indicative rather than exhaustive. Also, it is not a static list. It changes when objectives change, needs (problems) change, new discoveries are made, etc. The reader should take a good look at Appendix C to gain an appreciation for the scope of the Federal research and development effort. The reasons for the huge amount of assets dedicated to Federal research and development should become more apparent as the reader looks over this list.

Sources of information available to use in determining what the Federal research and development efforts are, past and present, will be presented in a later section.

The number of inventions, discoveries, and developments that have resulted from Federal research and development over the years is commensurate with the effort. Computers, jet transportation, microelectronics, antibiotics, yellow-fever eradication, chlorination of water, helicopters, space communications, radar and nuclear power are but a few examples. There are approximately 28,000 patents issued to the Federal government at this time [Ref. 22], and Federally funded research and development produces approximately 2,500 new inventions each year [Ref. 23]. Just as with the research and development effort, the scope of these inventions and patents is extremely broad.

After reading this section on Federally Funded Research and Development, it is hoped that the reader would agree that the Federal research and development capability is both awesome and difficult to comprehend.

III. FEDERAL TECHNOLOGY TRANSFER EFFORTS

A. BACKGROUND

Technology transfer has long been recognized as a part of the Federal research and development effort, but not always by that name. Only within the past few years has technology transfer been viewed as a process which is far more encompassing than the limited view of earlier years, i.e., dissemination of information. In 1947 the Office of Naval Research established a Science and Technology Project at the Library of Congress, one of the functions of this organization was the exchange of scientific and technical information. This organization has continued in existence, under various names, until the present. Today it is known as the Defense Documentation Center (DDC) [Ref. 24, p. ii]. In 1958 the National Aeronautics and Space Act created the National Aeronautics and Space Administration (NASA) to conduct the nation's space exploration programs. The act specified that NASA provide for the widest practical dissemination of information concerning NASA's activities and their results. This led to the establishment of NASA's Technology Utilization Program with its objective of facilitating the transfer of NASA technology to other sectors of the national economy [Ref. 11, p. 5; Ref. 25, p. 1]. In 1963 a Federal government report entitled the "Weinberg Report" stated that the "Transfer of information is an inseparable part of research and development." [Ref. 24, p. i]

In more recent years the Federal government's interest in technology transfer has risen because it is seen as a means of helping to solve the nation's many urgent problems. In his Special Message to Congress on Science and Technology in 1972 the president said:

> "An asset unused is an asset wasted. Federal research and development activities generate a great deal of new technology which could be applied in ways which go well beyond the immediate mission of the supporting agency. In such cases, I believe the Government has a responsibility to transfer the results of its research and development activities to wider use in the private sector." [Ref. 26, p. 420]

The passage of the National Science and Technology Policy, Organization, and Priorities Act of 1976 reflected a growing concern of the Congress, and others, about the nation's scientific and technical information enterprise. This law addressed scientific and technical information and the dissemination or transfer of research results in 11 of its 45 major sections [Ref. 27, p. 1]. In the policy implementation section of Title I the law states:

> "It is a responsibility of the Federal Government to promote prompt, effective, reliable, and systematic transfer of scientific and technological information by such appropriate methods as programs conducted by nongovernmental organizations, including industrial groups and technical societies. In particular, it is recognized as a responsibility of the Federal Government not only to coordinate and unify its own science and technology *information systems, but to facilitate the close* coupling of institutional scientific research with application of the useful findings of science." [Ref. 3, p. 3]

The remainder of this section will be devoted to presenting descriptions of some of the Federal agencies' efforts at technology transfer.

B. MAJOR EFFORTS

There are numerous Federal agencies and subdivisions thereof that have personnel and offices that are tasked with the technology transfer function. Following is a description of some of these efforts. There will be no attempt to critique the appropriateness or effectiveness of these efforts in this section.

1. The National Technical Information Service

The National Technical Information Service (NTIS) of the Department of Commerce had its origin in 1946, as the Government's instrument for channeling captured German and Japanese research and technology to U.S. industry. At that time it was known as the Office of Technical Services. In the mid 1950's, as Federal government research and development efforts grew very large, the mission was expanded to provide a central public access point for resultant technical reports. NTIS was established in 1970 as an information service organization "for making the results of technical research and development more readily available to industry, business, and the general public by maintaining a clearing house for the collection and dissemination of scientific, technical and engineering information." [Ref. 8, p. 20] NTIS undertakes and develops products and programs having the potential for self-support which are appropriate for government instead of private enterprise. The products and services of NTIS are intended to increase the efficiency and effectiveness of the U.S. research and development enterprise. NTIS receives only minor support through Congressional appropriation, it recovers about 90 percent

of its costs from the sale of its products and services, very much like a business. [Ref. 28]

NTIS is the central Federal source of U.S. and foreign government sponsored research, development and engineering reports and other analyses prepared by Federal, state and local government agencies, their contractors or grantees, and by Special Technology Groups. Federal agencies are required to submit such unclassified reports. Other organizations, numbering in the hundreds, provide them through agreements with NTIS. NTIS is also a central source for Federally generated machine processable data files and manages the Federal Software Exchange Center. The NTIS information collection includes over one million research report titles, about 150,000 of which are of foreign origin and some 500,000 resulting from Federally sponsored research from 1964 to 1977. About 70,000 new reports are added annually. NTIS is the only central source of research reports and other analyses that are developed by the vast Federal network of departments, bureaus, and agencies.

All reports received by NTIS are indexed, abstracted, and announced to the public through a variety of publications. It should be remembered that the user must request and pay for these publications. The basic NTIS announcement vehicle is a series of newsletters entitled Weekly Government Abstracts. These abstracts provide 100,000 readers with summaries of research reports and other specialized information within two weeks of receipt by NTIS from the originating agencies. These abstracts provide maximum coverage in brief and convenient form at

minimal cost. Presently there are 26 subject areas in the series. New subject categories are added when subscribers' requirements are sufficient to justify a new bulletin and allow for recovery of production costs. The Weekly Government Abstracts published now are Administration, Agriculture and Food, Behavior and Society, Biomedical Technology and Engineering, Building Technology, Business and Economics, Chemistry, Civil Engineering, Communication, Computers, Control and Information Theory, Electrotechnology, Energy, Environmental Pollution and Control, Government Inventions for Licensing, Health Planning, Industrial and Mechanical Engineering, Library and Information Sciences, Material Sciences, Medicine and Biology, Natural Resources and Earth Sciences, NASA Earth Resources Survey Program, Ocean Technology and Engineering, Physics, Problem-Solving Information for State and Local Governments, Transportation, and Urban Technology.

In addition to published bulletins and announcements, descriptions of reports are stored in computer data base for retrieval on a customized basis to satisfy a very specific user information need and on a more general basis for anticipated users' needs.

NTIS distributes about 20,000 information products daily, making it one of the world's leading processors of specialty information. It ships its customers about four million documents and microforms annually. Some other subscription items offered by NTIS are Tech Notes (summaries of new applications for technology as developed by nine Federal agencies and their contractors). Research Reports, Aerospace

Medicine and Biology, Report of Navy Research Laboratory Progress, Foreign Translation from the Joint Publication Research Service, Foreign Broadcast Information Service, Internal Revenue Civil Tax Cases, Aircraft Accident Reports, Census Reports and Patent Subscription Service (more will be said about Federal government patents and NTIS in a later section).

The NTIS collection is the largest and best publically available pool of widely varied research results in the world. The best way for a potential user of NTIS information services to find out how NTIS can help him or his organization is to contact NTIS personally. [Ref. 8, pp. 20, 21; Ref. 12, p. D-6; Ref. 29, pp. 1, 2, 7]

2. Smithsonian Science Information Exchange

The Smithsonian Science Information Exchange (SSIE) was established in 1949, then called the Medical Science Information Exchange, by six Federal agencies engaged in the support of research in the medical science. It is now operated as a nonprofit corporation by the Smithsonian Institution. The SSIE assists in the planning and performance of research activities by providing up-to-date information about research in progress. The Exchange is the major national source for unclassified information on current and recently completed research in all fields of science, with emphasis on interdisciplinary relationships. The SSIE's active file contains information on 200,000 current and recently completed research projects collected during the last two fiscal

years. The current file contains 20,000 research projects in all areas of social sciences research. Approximately 60 percent of the projects on file are in the life sciences and 40 percent in the physical sciences. New projects are added daily and projects continuing over a number of years are updated annually. The SSIE compliments other scientific and technical information services. By supplying information on ongoing research, the critical gap between the start of a research project and the time its results are published is bridged. This time period is often measured in years.

More than 1,300 supporting organizations provide SSIE with timely project descriptions of high scientific quality. Research project information, normally registered at the time work is funded, is supplied by virtually all Federal agencies engaged in basic and applied research, state and local governments, nonprofit organizations, universities and colleges, and, to a more limited extent, individual investigators, private industry, and foreign research organizations. Approximately 80 percent of the information is supplied by Federal government agencies, from both in-house and out-house research.

Information received by SSIE is classified, indexed, and stored in computers in such a manner so as to provide the flexibility to retrieve project information in the variety of forms desired by its users'. The SSIE itself engages in research designed to improve methods for indexing, storage and retrieval of information about ongoing research.

The basic record in the SSIE system is the single-page Notice of Research Project (NRP). The NRP contains the following information about each project: project title, supporting organization name and project number, performing organization name and address, Name(s) of the investigator(s), period covered, level of funding, and a 200-word technical summary of the work to be performed. This information provides the user with an effective means for follow-up and an opportunity to expedite the exchange of more detailed information about problems encountered or preliminary results.

Some of the reasons individual investigators and research managers use SSIE are to:

1. avoid costly, unwarranted duplication of research effort and expenditure;
2. identify possible sources of support for research on a specific topic;
3. obtain leads to the published literature, unpublished monographs, participants for symposia, and the like;
4. identify information to support grant or contract proposals;
5. stimulate new ideas for research planning in experimental methods;
6. acquire data for use in technological forecasting and development;
7. survey broad areas of research to identify trends and patterns or to reveal gaps in overall efforts;

8. learn about the current work of a specific investigator or organization.

SSIE search services are provided only upon request and they are priced to cover costs. Among these services are:

1. Custom Search, search of the active file for NRP's on specific subjects by performing organizations, specific geographic area, or some similar criterion.
2. Research Information Packages, results of SSIE conducted searches of the active file on subjects of high current interest.
3. SSIE Science Newsletter, contains newest research information package titles plus articles of interest to the scientific community. Available on subscription.
4. Selective Dissemination of Information, regular updates of custom searches or research information packages. Available on subscription.

Other services include On-Line Search Service, Investigator Searches, and Historical Searches.

Searches may be ordered in person or by letter, telephone, or cable. [Ref. 8, pp. 197-8; Ref. 12, p. D-6; Ref. 30, pp. 1-7; Ref. 31]

3. National Referral Center

The National Referral Center (NRC) is a referral service that directs those who have questions concerning any subject to organizations, groups, services, libraries, centers, or individuals from which or

from whom authoritative information is available. The NRC is located in the Library of Congress and it is a function of the Science and Technology Division. Operation of the center is financed by funds appropriated by Congress; therefore, the services of the NRC are free, except that its publications are sold by the Superintendent of Documents, Government Printing Office.

The NRC has three basic tasks:

1. inventory all significant U.S. information resources in specialized fields, including both the "for profit" and "not for profit" elements;
2. provide any individual or organization, on request, with information regarding these resources;
3. compile and publish directories and other listings of information resources.

The referral center does not furnish answers to specific questions or provide bibliographic assistance (the center does furnish titles of abstract journals, indexes, and directories when they are particularly relevant to the inquiry). Instead, it directs those who have questions to resources that have the information and are willing to share it with others.

The NRC presently has a subject-indexed, computerized file of 13,000 organizations and individuals that make up the center's "information resources." The file description of each resource includes its special fields of interest and the types of information service it provides.

The NRC file is maintained by professional analysts and is used primarily by the center's referral specialists. This computerized file is available through computer terminals located in some Library of Congress reading rooms and to many Federal agencies nationwide through a Department of Energy computer network called RECON.

The NRC actively seeks out and invites organizations and individuals that have information in specialized fields to participate as information resources. The criterion for registering an organization is not size but ability and willingness to provide information to others on a reasonable basis.

Requests for referral services are made by letter, telephone, or in person. The NRC encourages requests by telephone or in person to allow for discussion and refinement of complex questions. The center will accept requests on any topic. If a subject is not covered in the data file, the center will attempt to locate new information resources.

The reply to a referral services request is usually in the form of a computer printout and it contains the names, addresses, telephone numbers, and brief descriptions of appropriate information resources. In each case, the response is individually tailored to the specific request.

The NRC makes a sharp distinction between referral and reference activities.

> "The center's purpose is not to duplicate what libraries and information centers are already doing and are organized and equipped to do; it hopes to go beyond that both in variety and specificity - to make ever more

precise linkages between the user and the place where the highly specialized information that the user requires is to be found." [Ref. 32, p. 127]

The NRC tries to establish the most direct contact possible between people looking for information and those who can provide it.

Occasionally the NRC compiles directories of information resources covering a broad area; Water, General Toxicology, Social Sciences, Biological Sciences, and Physical Sciences, Engineering are examples. These are published by the Library of Congress under the general title A Directory of Information Resources in the United States with subtitles as listed above. These may be purchased from the Superintendent of Documents, U.S. Government Printing Office.

The NRC also issues informal lists of resources that have information on specific topics, such as population, environmental education and hazardous materials. These are available free of charge from the center for as long as they last.

In 1974 the head of the Science and Technology Division, Library of Congress said the following about NRC publications:

> "Publications should not be overemphasized; they are not really paramount. The center heartily subscribes to the conviction that scientific and technical information is most effectively transferred from person to person, not from media to people. NRC is therefore most concerned with putting people in touch with people, with the communication of facts and ideas directly from one human mind to another." [Ref. 32, p. 129]

The NRC continually evaluates its services by follow-up letters. It has determined that users receive the information they need about 82 percent of the time.

A good analogy for the National Referral Center is to think of it as a kind of technical equivalent of the telephone directory's "yellow pages," directing inquiries to reliable, expert information on particular topics. [Ref. 32, pp. 126, 127, 129; Ref. 33; Ref. 34]

4. Federal Laboratories

As shown earlier, the Federal laboratories have amassed considerable expertise and facilities that can be brought to bear on the problems confronting state and local governments and that can be applied in the private sector. In addition, the products of the Federal laboratories research and development efforts often have potential for use by state and local governments as well as for commercialization in the private sector. In most cases the product must be adapted for "secondary utilization."

This section will cover the utilization or application of Federal laboratory expertise by state and local governments and the private sector. Section IV will cover the transfer of Federal government research and development products to nonfederal users for utilization and/or commercialization.

The potential areas for the utilization of Federal laboratory expertise is as broad as the expertise itself. State and local governments face such real world problems as fire technology, systems analysis, crime detection, treatment of drug addicts, corrections, building standards, emission monitoring, product safety, environmental impact assessment, power plant siting, automatic data processing, noise

abatement, fuel conservation, occupational safety and health, wetlands management, air quality control and coastal zone protection [Ref. 35, p. 27].

The following was a policy position that came out of the 1973 National Governors' Conference:

> "The application of technology to the many significant problems faced by the States today offers considerable potential for improved effectiveness in state government policymaking and operations. Hence, the National Governors' Conference supports federal and state actions designed to increase the attention being paid to domestic problems by the research and development community of the Nation, and supports the dedication of federal government resources in support of problem-oriented research designed to provide policy analysis and options to state government decision-makers." [Ref. 35, IFC].

While state governments realize that the answers to many of their problems lie in technology, their resources do not allow them to develop the needed technology. State funds are almost entirely spent for the purchase of proven technology with little remaining for research and development. Historically, the total funding for research and development by all states is only about one percent of the Federal allocation for research and development [Ref. 15, p. 13; Ref. 35, p. 35]. It is not unusual for the Federal government to contribute more funds to the states for research and development than the states themselves expend for that same purpose [Ref. 35, p. 31]. This is where the already existing Federal laboratory expertise can help.

The Federal laboratories also possess some unique capabilities and expertise that nongovernment organizations, including private

industry, have requirements for. Examples are numerous types of test ranges, deep submersible technology, and satellite technology.

The existence of two general types of Federal laboratories require that the remainder of this section be presented in two parts, civil-mission laboratories and special mission laboratories.

a. Civil-Mission Laboratories

As pointed out earlier, civil-mission Federal agencies have an inherent need to work closely with state and local governments, and in some cases the private sector, in the performance of their missions. Ensuring the effective and efficient utilization of the various civil-mission Federal laboratories is mainly a problem of determining in what areas the assets of these laboratories will be applied so as to maximize the benefits to the country. There is also the problem of coordination of the Federal effort by these agencies to prevent the waste of Federal assets through duplication of programs. The coordination of Federal effort to prevent duplication applies to special-mission agencies also. Due to the already mentioned fragmented nature of the Federal laboratories, this coordination problem is no small task.

One way that civil-mission agencies attempt to determine what research and development their laboratories will pursue is through what is known as the Outreach Program. This program utilizes the division of the U.S. into ten Federal Administrative Regions. Utilizing these ten regions is a recognition of the fact that state and local governments are not carbon copies of each other. Their problems, institutions,

and capabilities differ widely. These differences must be understood by research and development centers, or technology transfer arrangements may fail through misunderstanding and clumsiness. State and local governments are not one, but many, markets for laboratory services. In each region there is a Federal Regional Council, made up of representatives from the various civil-mission agencies, whose job it is to identify the problems faced by the state and local governments that their agencies can appropriately assist in solving. This is done by soliciting inputs from governors, mayors and other state and local officials (fire chiefs, city managers, police chiefs, etc.), conducting polls, conferences, meetings, etc. The emphasis is on personal contact. The results of these efforts are prioritized and sent to Washington.

The inputs from the regional councils are collected and prioritized at the national level. The prioritization, at the regional and national level, is governed by such things as the number of state and local governments with a similar problem, the number of people that will benefit, the urgency of the problem, etc. The civilian-mission agencies then attempt to develop solutions to the problems that are appropriate to their particular mission, <u>within</u> the constraints of their budget. Not all problems can be addressed. [Ref. 35, p. 15; Ref. 36]

The Outreach Program is not the only means that Federal civil-mission agencies use to determine needs of state and local governments, nor is it the only means these governments use to relay their needs to the agencies. A number of agencies, like the Department of

Agriculture, have personnel located throughout the United States who have, as one of their responsibilities, the determination of needs. There is Public Technology Incorporated (PTI), a nonprofit, tax-exempt public interest organization started in 1971 by six public interest groups representing state and local governments (Council of State Governments, International City Management Association, National Association of Counties, National Governors' Conference, National League of Cities, and U.S. Conference of Mayors), an institutional mechanism for applying available technologies to the problems of state and local governments [Ref. 4, p. 25; Ref. 37, p. 65]. There is the Urban Consortium for Technology Initiatives, its primary function is to identify and define local research and development needs so that they can be effectively communicated to appropriate offices at the Federal level [Ref. 4, p. 26]. There are other examples of collective state efforts to define problems and to seek solutions with the help of the Federal government and/or private industry. These efforts may be on a regional or a national level and on a continuous or special purpose basis.

Once problems have been selected for attempted solution by the laboratories, it is widely recognized that the state and local government people should be involved in the effort to arrive at solutions so that the social, political and economic environment in which the solutions will be applied will receive appropriate consideration. The whole process should be a cooperative, person-to-person effort. This has not always been the case in the past nor is it always the case today. The

The following is a quote by a state legislator from testimony before a 1975 U.S. House of Representatives hearing concerning the intergovernmental dissemination of Federal research and development results:

> "Most federal technology transfer efforts, including the RANN (Research Applied to National Needs) program of NSF (National Science Foundation), as viewed from the states' perspective could be typified as a "push" program. The states are viewed more as uninformed customers rather than as an intelligent user community, capable of defining their problems and thus providing a focus for "application" needs." (parentheses added) [Ref. 4, p. 18]

Federal agency attempts at helping state and local governments with their problems, although well intentioned, too often come across as the insensitive force feeding of high technology solutions for perceived needs.

It is possible for a state or local government or a private sector organization (profit or nonprofit) to fund research and development in a civil-mission agency laboratory; however, an extensive process of approvals and bureaucratic decision-making must ensue before a laboratory can undertake any work [Ref. 35, p. 22]. More will be said about this type of activity in the following section on special-mission Federal laboratories. Suffice it here to say that it is easier for civil-mission type laboratories to gain approval for this kind of work because it is specifically their agencies' mission to work in the civilian (non-federal) area.

The problems depicted above and the coordination and duplication problems are technology transfer problems. These problems are recognized and efforts are being made to improve the situation.

b. Special-Mission Laboratories

The special-mission Federal agencies (DOD and NASA) possess a vast array of laboratories. These laboratories generally require a higher technology than the civil-mission laboratories and they do not have an inherent need to work with state and local governments or the private sector. The expertise and facilities of these laboratories were described earlier. The DOD laboratories comprise a large percentage of the special-mission Federal laboratories; therefore, this section will be concerned with DOD laboratories only. The NASA efforts in technology transfer will be described briefly in section III. B. 5.

When talking about technology transfer and special-mission laboratories it is important to remember that special-mission laboratories are just that - special mission. The mission of the DOD and its agencies is to provide for the national security. The definition of "national security" can be a thorny issue. DOD agencies tend to view their national security mission in national defense, militaristic terms. Other government agencies and private sector organizations (profit and nonprofit) tend to view it more along the lines of national welfare. When considering the use of DOD laboratory capabilities for solving pressing human problems, the following quote reflects the prevailing view of state and local governments, "Pinned down to their national security mission only, they are not being utilized in the true sense for 'national security' purposes if that term is understood to equate with national interest." [Ref. 35, p. iii]

The president's message to congress in 1972, referred to earlier, in which he called for finding ways of assuring state and local governments adequate access to the technical resources of major Federal research and development centers was a milestone in the effort to increase the use of these laboratories in seeking solutions to problems facing all levels of government and private organizations. Secondary utilization of research and development was also addressed in a 1972 memorandum by the Deputy Secretary of Defense to all military services as a means of enhancing the productive output of DOD's research and development effort [Ref. 38, p. iii].

One of the ways that DOD laboratories attempt to utilize their expertise for the benefit of other government agencies and the private sector is to undertake, to the maximum extent possible but consistent with their national security mission, programs that have high potential for secondary utilization. Products that result from such effort must then be transferred to the secondary user, this process will be discussed in Section IV. Another way is for Federal laboratories to contract to perform work for other government agencies and private sector organizations.

There are a number of guidelines to be considered before a DOD laboratory can contract to perform such services; they are:

1. the laboratory must possess unique expertise and/or facilities.

2. the intended effort cannot interfere with mission effort, i.e., compete with mission projects for personnel or equipment. Staff or facilities will not be added for such work.
3. the laboratory will not compete with competent private groups or industries that can do the job. The objective is to stimulate and assist the industrial sector, not inhibit or discourage it.
4. because of the unique capability, the laboratory must be able to perform the work at a significant savings in time and dollars over private sector organizations (at least ten percent less in cost).
5. the total level of effort applied to mission-oriented, non-agency problems will not exceed three percent of the professional man-years at that laboratory without approval from above the laboratory director level (1974 Director, Defense Research and Engineering memorandum).
6. such work will be performed on a reimbursable basis, including a realistic overhead cost.

In a DOD laboratory approval to contract for such work normally comes from the director or a lesser official, depending on the size of the project. As can be seen from the guidelines above, the person approving such a contract will have to make a number of judgmental decisions. [Ref. 35, pp. 7, 12; Ref. 36]

A recent situation presents an example of state governments and private industries seeking assistance from a DOD agency. In early 1978 there were two incidents of explosions in very large grain elevators which resulted in millions of dollars of damage and the loss of about forty lives. The governors of a number of states where such facilities are located are seeking the assistance of the U.S. Army in determining the cause of the explosions and resolving the problem. Why the Army, because it has considerable expertise in defuzing explosives and explosive environments which may prove very helpful in this situation. The Army will be reimbursed for its efforts [Ref. 36].

Except for the debatable effects of the Mansfield Amendment on DOD laboratories, there appears to be no <u>legal</u> impediment to the wider use of Federal research and development laboratories and research centers in assisting state and local governments in applying technology. Services for other Federal agencies are permitted under the Economy Act. In the case of DOD laboratories, the so-called Mansfield Amendment prohibits the use of Federal <u>funds</u> for research and development not directly pertinent to the national security mission. However, with the policy of reimbursement of costs the Mansfield Amendment is not the barrier to technology transfer that it is alleged to be. [Ref. 35, pp. 8, 9; Ref. 6, p. 5].

A barrier that many do perceive to the acceptance of research and development work from state and local governments and

the private sector is personnel ceilings. There is concern in DOD that accepting such work while under the restriction of personnel ceilings will dilute the defense mission of the DOD laboratories. Mission priorities drive out desirable but discretionary efforts. Even if a laboratory were able to perform its mission and do a limited amount of "contract" work, there is the fear that the assets devoted to such work will be viewed by higher levels of management as excess to mission needs and therefore subject to "removal" in a budget squeeze. While such fears may seem far fetched to the reader, they are very real to laboratory management. It is a fact that there are DOD laboratories that discourage contract work with state and local governments and the private sector for just such reasons. [Ref. 35, pp. 8, 12; Ref. 36]

There is an alternative to the use of Federal laboratories, that is the use of Federal contract laboratories (or Federally Funded Research and Development Centers). These laboratories have unique characteristics that make state, local and private sector projects feasible. Because these laboratories are not directly government operated they are not restricted to manpower ceilings (except by budget considerations) or by Civil Service restrictions. They can therefore be more aggressive in pursuing intergovernmental and private sector projects; however, they must be careful not to compete with private industry in the private sector. [Ref. 35, pp. 33, 42]

For whatever reasons, the Federal laboratories, both civil-mission and special-mission, have not and are not doing a

"landoffice business" with state and local governments when it comes to contracted research and development work. It is estimated that in 1977 state and local governments "accounted for only one percent of the Federal research and development total." [Ref. 15, p. 13]

5. Others

As a developer of new technology, the National Aeronautics and Space Administration (NASA) is probably more directly tasked with the transfer of its technology than any other such agency. The need to maximize the utilization of the vast amount of scientific and technical knowledge that is generated by NASA was recognized from NASA's inception in 1958. This fact led Congress to call for the following in the 1958 Space Act, "long-range studies of the potential benefits to be gained from, and the problems involved in, the utilization of aeronautical and space activities for peaceful and scientific purposes." NASA was charged with the obligation to "... provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof." [Ref. 8, p. 153] NASA performs its technology transfer function in a number of ways. Some of them are described below.

The Technology Utilization Program attempts to ensure that new space technology is brought to the attention of other Federal agencies, state and local governments and private industry so it may be adapted and applied for the user's benefit. Flexibility and responsiveness to the user's needs are underlying features of this program's major elements. Some of these elements are:

1. New Technology Identification and Evaluation. New innovations and developments are evaluated and announced as publicly available, if appropriate, in NASA Tech Briefs. A separate section of these briefs focuses attention on innovations believed to have potential for commercialization.

2. Industrial Application Centers (IAC's). Six centers located at universities across the country that provide all users with retrospective searches, current awareness searches, and technical assistance designed to help industry apply the results of existing research and technology. Experienced "technology coordinators" are placed at several of these centers to match problems posed by users to appropriate NASA scientific and engineering expertise.

Other elements include the Computer Software Management and Information Center and the Public Sector Application Teams, which include engineering.

Technical Application Programs meet specific, identifiable civil needs. The systems developed are within the mission responsibility of other government agencies and must receive their support to be put into operational use. [Ref. 8, pp. 153-7]

NASA has received a considerable amount of publicity over the years concerning the benefits to the nation that have resulted from "spin-offs" and secondary utilization of NASA generated technology.

As demonstrated by the following quote, from a 1977 NASA administration letter to all center directors, the importance of the technology transfer effort is not lost on NASA officials:

> "The success of the Technology Utilization Program can have a major bearing on the support we receive for our flight programs and for NASA itself. This has been well illustrated in several of the Congressional hearings during this year's budget review." [Ref. 25, p. 1]

Another organization active in promoting the transfer of technology is the Federal Laboratory Consortium for Technology Transfer. The consortium is an informal organization of 71 major Federal research and development laboratories and centers representing the Department of Defense, Department of Transportation, National Aeronautics and Space Administration, Department of Commerce, and the Department of Energy. The consortium had its beginning as the DOD Laboratory Consortium, in 1973, it encompassed 21 laboratories [Ref. 35, p. 27]. Today the consortium is open to all Federal agencies and its membership is increasing steadily. The purpose of the consortium is to increase the use of member laboratories' unique technical expertise and research and development products to help solve problems facing our government agencies, all levels, and private industry.

Technology transfer is accomplished in a variety of ways by the consortium. DOD laboratories perform civilian oriented research and development, funds provided by the requesting organization, based on earlier research performed for military purposes. Non-DOD

laboratories attempt to increase the use of their research results by decision makers and operational agencies in the public and private sectors. Scientists are temporarily exchanged between the Federal agencies and between Federal and local government organizations through the provisions of the Intergovernmental Personnel Act of 1970. Member laboratory personnel assist state and local governments by serving on scientific advisory boards, acting as consultants to specialized groups (such as law enforcement), providing library services, and identifying sources of surplus government equipment.

Each of the member laboratories has a technology transfer coordinator. These individuals are the points of contact for technology transfer matters at the laboratories. These individuals maintain contact with their counterparts in other consortium laboratories and in other Federal agencies which have technology transfer programs but are not consortium members. They are also frequently exposed to new technologies developed by private organizations and state and local governments. Because of the above mentioned activities, these technology transfer representatives become familiar with a variety of technical resources beyond their own laboratories. With this familiarity the representatives can often bring together the user that has a problem with those who have already solved it, or who are working in that area. This "technology broker" type service has been very useful to state and local governments who are often unaware of the scientific support available in the Federal laboratories. [Ref. 39]

The Federal Laboratory Consortium for Technology Transfer has a permanent representative in the Office of Intergovernmental Sciences and Public Technology, National Science Foundation. The consortium member laboratories, each with its consortium representative, are located in approximately 32 states. These representatives make the consortium more accessible than most technology transfer organizations.

The consortium is funded mainly by the member laboratories; however, some support from the National Science Foundation is received.

The consortium effort could best be described as an informal, person-to-person technology transfer effort.

There are many more Federal agencies, mostly civil-mission but also some special-mission, that engage in various technology transfer efforts; however, the foregoing examples acquaint the reader with some of the things being done.

IV. PATENT POLICY AND TECHNOLOGY TRANSFER

A. GENERAL PATENT POLICY

The Constitution of the United States states that "Congress shall have power ... to promote the progress of science and useful arts, by securing for limited times to the authors and inventors the exclusive right to their respective writings and discoveries." [Ref. 40, p. 3] The first patent law was enacted in 1790. Through the years the patent laws have been modified, revised, and rewritten. The law presently in effect was enacted in 1952. This law states that any person who "invents or discovers any new and useful process, machine, manufacture, or any new and useful improvements thereof, may obtain a patent," subject to the conditions and requirements of the law [Ref. 40, p. 3]. This section will not address the conditions and requirements of patent law, it will address the intent and effect of patent law.

The purpose of the patent system is to encourage invention and innovation and the resulting economic development benefits to the nation [Ref. 41, p. 65]. The individuals and institutions that possess patentable inventions may very well have invested considerable time, effort and money in developing them. "If they could not recover their investment and make a reasonable profit, what incentive would there be to pursue ideas and concepts which could lead to inventions for the betterment of all mankind?" [Ref. 42, p. 33] The objective is to gain the

maximum benefit from each technological development for society while also creating a fertile environment for continuing technical advancement. The framers of the Constitution felt that the grant of a limited monopoly to an inventor would result in a much greater benefit to society than to the inventor.

There are few that would not agree that the granting of patents by the Federal government has resulted in great benefits to the nation. The following quotation expresses that viewpoint:

> "Our current patent policy is an expedient to ... technology transfer. Our patent system was created to benefit society. It is only in the public's interests that patents are granted. Technological progress has been shown to be greatest when the inventor is given a reward for his efforts. Our patent policy is to reward the inventor in the form of a limited monopoly; in exchange, their technology is transferred into public domain ...
>
> The principle underlying all government actions by which our present patent system has evolved, is to serve the public through technology transfer." [Ref. 42, p. 43]

The role of the Patent and Trademark Office of the U.S. Department of Commerce is to assist and encourage the development of the business and industry of the United States. By providing patent protection for inventions, by advising and assisting other agencies of the government in matters involving patents and inventions and the transfer of technology, and by the preservation, classification, and dissemination of patent information, the Patent and Trademark Office aids and encourages innovation and the scientific and technical advancement of the nation.

The U.S. Patent Office has information on file on over four million domestic patents and seven million foreign patents. This patent information is carefully defined by technical categories. These patents can be searched by subject category only through the Washington, D.C. area Patent Office. The Patent Office provides numerous publications and services to assist the general public and other users in searching and reviewing this vast amount of readily available information. Such efforts can be utilized to provide familiarization with prior approaches to resolve a particular problem, to evaluate the novelty of a proposed approach to a problem, and to identify approaches which may be covered by patents. The knowledge gained can result in cost savings by avoiding the unnecessary expense of duplicating the previous efforts of others and possible patent infringements. [Ref. 12, p. 2-13; Ref. 40, p. 16]

B. GOVERNMENT PATENT POLICY AND FEDERAL RESEARCH AND DEVELOPMENT

1. Federal Laboratories

There is no doubt that patent rights in inventions resulting from Federally funded research and development conducted in Federal laboratories and research centers belong to the government. The evaluation of government patents for commercialization and secondary utilization and the methods to achieve those ends will be presented later.

Inventions that originate in civil-mission laboratories will usually have direct civilian application due to the type of research and development that these laboratories undertake. They may also have secondary utilization potential.

Inventions that originate in special-mission laboratories are almost never in a form so that they may be transferred directly to the marketplace and usefully applied. There is almost always a need for product modification. This usually involves considerable technical and financial risk. [Ref. 8, p. 155; Ref. 13, p. 20] Special-mission laboratories are very seldom funded for such effort simply because it is not seen as part of their mission, and the laboratories often do not desire to do such work for fear it will dilute their special-mission efforts.

2. Federally Funded Private Sector Research and Development Contracts

For over thirty years there has been a controversy over what the Federal government's policy should be with respect to patent rights in inventions resulting from Federally funded research and development contracts with private sector organizations, profit and nonprofit. Presently there is no general legislation that controls all Federal agencies in the disposition of rights to such inventions. Federal agencies have widely varying policies with regard to taking title to patentable inventions made under such contracts; however, these can be generally grouped under two policies, the so-called "title" and "license" policies. Under the "title" policy the government takes title to the rights in these inventions (i.e., patents) and then allows private interests to utilize the inventions through licensing. Under this policy the government may choose not to patent the invention, but to publish it instead and thereby

make it available to anyone and everyone. The "title" viewpoint is basically that any inventions which result from Federally funded research and development should be the property of the government. To give companies the rights to such inventions is in effect a double charge on the public: first for the research and then for the monopoly profits resulting from such "giveaways." Under the "license" policy the contractor is given title to the rights in the inventions, with a royalty-free license retained by the government; however, there is no obligation on the part of the contractor to let other qualified applicants have access to the products of government funded research. The "license" viewpoint is that the public will best be served by this type contract because the most qualified contractors will compete for the contracts and because private industry is best equipped for developing and promoting such inventions. Whatever the policy, it must be delineated in the contract in the form of a patent clause.

In 1963 President Kennedy issued a Statement of Government Patent Policy which took the position that one single patent policy was not appropriate, a more flexible policy was required. This statement took a middle ground approach to the "title" and "license" policies and described in general terms those conditions under which the government would take title and those under which it would only take license. A 1971 presidential statement on the same topic, a slightly modified version of the 1963 statement, now guides Federal patent policy with

respect to the disposition of rights to inventions made under Government sponsored contracts and is implemented by the regulations of various agencies. This statement recognizes the inventions in scientific and technological fields resulting from such contracts as a valuable national resource and states that:

> "The public interest in a dynamic and efficient economy requires that efforts be made to encourage the expeditious development and civilian use of these inventions. Both the need for incentives to draw forth private initiatives to this end, and the need to promote healthy competition in industry must be weighed in the disposition of patent rights under Government contracts." [Ref. 43, p. 1076]

The position is that the ownership of inventions resulting from research and development contracts cannot be determined in advance by an arbitrary or fixed rule but must be decided in each instance in accordance with the facts involved. [Ref. 41, p. 12; Ref. 44, pp. 2, 3]

The patent policy with respect to inventions developed under government contracts requires the responsible officials in the numerous Federal government agencies involved to interpret the general policy and to make many judgemental decisions. In each instance the ultimate criterion to be used is "what would best serve the public interest?" Given the complexity of the situation and the latitude that exists, it should not be surprising to find the widely varying policies that are in effect.

Considering the fact that over half of the Federal government's research and development effort, $26 billion in 1978, is contracted out

to private industry, the "stake" that the public has in resulting inventions is not insignificant.

3. Government Patents

Federal laboratory employees are required by law to report fully any new technology they develop in the course of their work. Contractors doing research and development for the Federal government are required by their contracts to do the same. The reason for this requirement is so that the new technologies can be evaluated for further government applications, patenting, adaptation for secondary utilization, and commercialization. The main objective is to achieve optimum technology utilization. A secondary reason, which actually results in more government patents, is to protect the Federal government from future claims for royalty payments.

In Federal agencies, especially special-mission type, the motivation to report and export for commercial consumption the technology developed in support of public policy and projects is lacking. The primary urge of these scientists, once a project is completed, is to "get on with the next one." [Ref. 37, p. 54] In addition, the bureaucratic, red tape, paper work shuffle that the inventor must go through to report an invention (an invention he very often considers trivial and insignificant) is a demotivating factor [Ref. 45].

All Federal agencies that sponsor research and development have a procedure by which they evaluate new inventions developed.

Thes procedures vary between agencies. It is up to the individual agencies how they will publish and promote those inventions which are evaluated as having potential for wider use, secondary utilization and/or commercialization. An invention may be made generally available by publication, known as dedication, or it may be made available through licensing after being patented. Each agency patents its own inventions. Licensing may be exclusive or nonexclusive and royalty bearing or royalty free. Whatever the method, the rational is that Federal government inventions normally will best serve the public interest when they are developed to the point of practical application and made available to the public in the shortest possible time so as to assist in the accomplishment of the national objective to achieve a dynamic and efficient economy [Ref. 46, p. 1].

When an invention is patented, the granting of a nonexclusive license is generally preferable since the invention is thereby laid open to all interested parties and serves to promote competition in industry. However, to obtain commercial utilization of an invention, it may be necessary to grant an exclusive license for a limited period of time, normally not to exceed five years, as an incentive for the investment of risk capital to achieve practical application. Whenever an exclusive license is deemed appropriate, it must be negotiated on terms and conditions most favorable to the public interest and only after:

1. The invention has been published in the Federal Register, the Official Gazette of the U. S. Patent Office, and at least one other publication, as being available for nonexclusive licensing for a period of at least six months;

2. it has been determined that the invention may be brought to the point of practical application by exclusive licensing and that the desired practical application is not likely to be achieved expeditiously in the public interest under a non-exclusive license or as a result of further Government funded research and development;

3. the notice of the prospective exclusive license has been published for at least 60 days. [Ref. 47, pp. 3329-30]

Royalty fees are not normally required from licensees because such fees would be passed on to the public in the form of higher prices for resultant products.

An application for nonexclusive license will contain, among other things, a statement of the purpose for which a license is desired, a brief description of the applicant's plan to achieve that purpose, and some indication of how the granting of a license would be in the public interest. In addition, an application for exclusive license will indicate if the applicant is a U. S. citizen, identify any other exclusive licenses or license applications held, and provide a statement of capability to undertake the development and marketing required to achieve the

practical application of the invention and the intention to perform such acts.

> "In selecting an exclusive licensee, consideration shall be given to the capabilities of the prospective licensee to further the technical and market development of the invention, his plan to undertake the development, the projected impact on competition, and the benefits to the Government and the public. Consideration shall be given also to assisting small business and minority business enterprises as well as economically depressed, low income, and labor surplus areas, and whether each or any applicant is a U.S. citizen or corporation." [Ref. 47, p. 3329]

Licenses are subject to reservations. As a minimum, nonexclusive and exclusive licenses will be revocable and provide for royalty free reservation rights in the invention to the United States Government.

The National Technical Information Service (NTIS) is the central government information source for all government inventions. There are over 28,000 government owned patents. The NTIS has some 16,000 of these patents issued from 1966 through 1974 cataloged and available for licensing. The patents cover all fields of science and technology and many have applications beyond their original design; however, only a small percentage of these have been commercialized or put to wide use.

Since 1972 all government agencies submit their new inventions to NTIS when they file for a patent and again when patents are issued. All these inventions are listed in a weekly NTIS illustrated newsletter entitled Government Inventions for Licensing. All inventions are

evaluated by NTIS and the most commercially promising inventions are summarized in another publication, Selected Technology for Licensing. More than 2,000 government inventions are patented annually by the government and processed by NTIS. On selected inventions, NTIS obtains foreign patent protection to provide U.S. firms with a more attractive licensing package and to insure royalty income from foreign users if no U.S. firms are interested in the foreign markets.

Since NTIS started evaluating government patents for commercial application in the early 1970's, it has continually tried to improve its evaluation system. The quality and quantity of the inventions that are eventually transferred to society is directly related to the level of sophistication of the screening device employed. The initial screening device assumes even greater importance when the cost of commercialization of an invention is compared to the cost of invention itself. As a general rule of thumb, the cost of developing and commercializing a new invention is ten to 100 times as expensive as attaining the invention, and there is no guarantee that the new product will be successful in the marketplace [Ref. 12, pp. 2-8, 9]. The NTIS has contracted out a number of studies in an effort to improve its evaluation system and it will very shortly contract out for additional evaluation capability to supplement its in-house capability. [Ref. 22]

In addition to Department of Commerce inventions, custody of inventions from other departments may be transferred to NTIS for

promotion, foreign filing, and licensing. Where inventions have not been assigned to NTIS, prospective licensees are referred to the appropriate agencies.

NTIS promotes licensing through seminars, exhibits, and direct contact with prospective licensees. Nominal fees and royalties are normally charged to permit NTIS to operate its patent program on a self-sustaining basis. [Ref. 29, pp. 14, 15]

About one government patent in ten is selected for promotion by NTIS, about one in 100 is selected for "heavy" promotion. In 1976 about 150 government patents were licensed by all Federal agencies out of over 2,000 government patents issued. [Ref. 22]

Although the number of patents issued should not be considered the sole indicator of research and development effectiveness and efficiency, it is interesting to note that in recent years the proportion of patents issued to the Federal government on a yearly basis was less than five percent of the total number of domestic patents issued [Ref. 48, p. 41]. In the same period the Federal government provided about 65 percent of all funds spent on research and development in the United States.

The patenting of inventions that result from Federally funded research and development provides the government with a means for moving technology from the public sector to the private sector.

V. THE NATIONAL SCIENCE AND TECHNOLOGY POLICY, ORGANIZATION, AND PRIORITIES ACT OF 1976

In May 1976 the National Science and Technology Policy, Organization, and Priorities Act was signed into law. This act created the Office of Science and Technology Policy (OSTP) in the Executive Office of the President to provide advice on the scientific, engineering, and technical aspects of issues that require attention at the highest levels of government [Ref. 3, p. 5]. This act had numerous provisions addressing technology transfer and there were many who predicted that it would strengthen the emphasis on technology transfer and provide the centralized Federal direction and coordination with respect to research and development and technology transfer that had been lacking in the Federal government agencies and between those agencies and state and local governments [Ref. 49, p. 25]. It should be noted that OSTP does not have direct authority over other Federal agencies, it is an advisory office to the president. OSTP policies would have to be issued in an executive order to be binding on Federal Executive agencies. OSTP has a working relationship with other Federal agencies and state and local governments. The duties of OSTP include the following [Ref. 27, p. 22]:

1. "Gather, analyze and interpret timely and authoritative information concerning significant developments and trends in science and technology"

2. "Utilize, to the fullest extent possible, the services, personnel, equipment, facilities and information ... of public and private agencies and organizations, and individuals, in order to avoid duplication of effort and expense"

Two groups created within OSTP are listed below with their membership and a general description of their objective.

1. Intergovernmental Science, Engineering, and Technology Advisory Panel:

   . Director of the National Science Foundation plus ten or more members from states.

   . "Advise and assist the Director in identifying and fostering policies to facilitate the transfer and utilization of research and development results so as to maximize their application to civilian needs" [Ref. 27, p. 22].

2. Federal Coordinating Council for Science, Engineering, and Technology:

   . Thirteen members, one each from the major Executive agencies (DOD, NASA, HEW, DOA, etc.).

   . "Achieve more effective utilization of the scientific, engineering and technological resources and facilities of Federal agencies, including the elimination of unwarranted duplication" [Ref. 27, p. 22].

The 1976 act also established a committee to conduct a two year comprehensive survey of all aspects of Federal research and development activity, including technology transfer [Ref. 27, p. 1].

It is too early to tell if the National Science and Technology Policy, Organization, and Priorities Act of 1976 will achieve its objectives

and/or live up to the expectation some hold for it. In addition to being a very new organization, key personnel in OSTP changed with the incoming of a new president in 1977.

There are some who would argue that although further study and policy guidance are required, what is needed now to increase science and technology utilization through technology transfer is more positive action. They would point toward development of specific approaches through legislative action [Ref. 4, p. III]. They would point out that there have been many studies completed already and many policy statements made and that there already exists some agreement on what needs to be done. What is needed now, in the place of "lip service," is some funding, personnel, and strong top management support to do those things. At a time when they are having to more completely justify their funding requests, special-mission agencies are especially wary of policy statements which encourage discretionary programs that are not backed by such support. The passive techniques of technology transfer in the Federal sector must continue (collecting, screening, indexing, storing, and disseminating scientific and technical information); however, more emphasis on active methods is required (problem definition, adaptation for secondary utilization, and a stronger Federal government patent program). The primary mechanism for technology transfer still remains personal relationships. "Given the nature of the technology transfer process, which is eyeball-to-eyeball, documentation strategies

are only facilitative of the mainline reliance on person-to-person interaction." [Ref. 35, p. 21]

Technology transfer is an "infant profession," much needs to be done to make its various functions fit together as a whole structure. The people involved in technology transfer must have, as a common denominator, "an active interest in seeing that useful technology does not lie fallow - that it be identified and used in the best way to help mankind help itself." [Ref. 9, pp. 5, 7].

VI. SUMMARY

The United States faces a multitude of problems which pose potential threats to its position in the world hierarchy and the standard of living and well being of its citizens. These problems are complex and broad based. They affect all levels of government and the private sector. The nation possesses the assets to successfully cope with its problems, and very important among these are its science and technology capabilities and potential. However, the outcome of the nations efforts at solving its problems is not assured. The magnitude of the problems, both in numbers and difficulty, requires the efficient and effective utilization of this nation's resources so as to optimize the solutions. The solutions that are sought from science and technology will come from research and development, and whether or not these solutions achieve their optimum utilization will depend to a great extent on how well they are "moved" to the problems. Therein lies the role of technology transfer, moving the solutions and potential solutions to the appropriate problems.

This paper has examined how the Federal government and its agencies perform their technology transfer function. The magnitude and scope of the Federal government's research and development efforts were demonstrated and some of the methods employed to transfer technology, as defined on p. 11, were presented. It is hoped that the

reader has gained an appreciation and an understanding of the need for and the objectives of the Federal government's technology transfer efforts.

APPENDIX A

TECHNOLOGY TRANSFER AND UTILIZATION

The basic process of technology transfer and utilization is applicable to the products of research and development from federal laboratories, universities, research institutions, industrial laboratories, and other sources, whether or not such activities are supported in whole or in part by federal contracts or grants [Ref. 13, p. 4].

STEPS TOWARD TECHNOLOGY TRANSFER AND UTILIZATION

The transfer and utilization of technology is a complex, non-linear process, comprising a number of dynamic steps that occur in varying degrees in a substantial portion of American industry today. Understanding this process is essential to understanding this report. COTTU (Committee on Technology Transfer and Utilization) has defined the steps as follows:

- Collecting, organizing, and storing the results of research and development (R&D) -- i.e., the technology.
- Publishing and disseminating the R&D information.
- Identifying a need and evaluating the technological requirements that must be met to satisfy it.

  (At this point the potential users are identified and the technology adapted or modified to meet their needs.)

- Matching of the available technology with the specific need or ultimate use, determined with the aid of the potential users.
- Executing a continuing series of relevant cost-benefit analyses.
- Defining the market potential and the other parameters that should help to determine the potential utilization.
- Examining the possible consequences that may result from fulfilling the needs and their impact.
- Locating the potential "suppliers" who are able and available to translate the technical information into practical reality.
- Determining resources and other requirements necessary for suppliers to produce the product, service or process.
- Associating the suppliers and users so they can agree on the standards, characteristics, performance, and constraints of the product, service or process.
- Performing the adaptive engineering necessary to develop the product or service or to acquire any missing elements.
- Establishing a business or implementation plan to determine production and operational costs.
- Acquiring the necessary financing.

- Creating a marketing plan, production of the product, service or process and implementation of its sale at a price a purchaser will pay.

These steps are not a rigid or orderly structure. In some cases the sequence may be different or random, in others certain steps may overlap. Some steps may require modification and iteration to meet particular circumstances. For instance, there may be several competing teams or combinations of users, suppliers, and innovators pursuing similar objectives, and at some stage particular participants may drop out, change course, or make some other accommodation.

The process of technology transfer and utilization as defined here may not be applicable to every case. The importance of each of the steps varies according to the nature and character of the market pursued and the personal or collective perspective of the innovators, suppliers, and users [Ref. 13, pp. 6-8].

APPENDIX B

Federal Outlays for Research and Development, by Agency,
Fiscal Year 1977
(estimated, millions of dollars)
[Ref. 15, pp. 67, 68]

Agency and Subdivision	Outlay
Total, All Agencies	23,595.9
Departments	
Department of Agriculture, Total	518.6
Agricultural Research Service	282.9
Cooperative State Research Service	123.8
Economic Research Service	25.0
Farmer Cooperative Service	1.3
Forest Service	83.6
National Agricultural Library	*
Statistical Reporting Service	2.0
Department of Commerce, Total	230.1
Bureau of the Census	1.3
Economic Development Administration	11.9
Maritime Administration	19.2
National Bureau of Standards	50.4
National Fire Prevention and Control Administration	4.2
National Oceanic and Atmospheric Administration	139.6
Office of Minority Business Enterprise	1.9
Office of Telecommunications	1.2
Patent and Trademark Office	.4
Department of Defense, Total	10,969.0
Department of the Army	2,405.7
Military Functions	2,390.6
RDT&E Appropriations	2,287.0
Pay and Allowance of Military Personnel in R&D	92.1
Military Construction	11.5
Civil Functions	15.0

Department of the Navy	4,118.5
RDT&E Appropriations	4,007.0
Pay and Allowances of Military Personnel in R&D	97.0
Military Construction	11.4
Special Foreign Currency Program	3.1
Department of the Air Force	3,740.3
RDT&E Appropriations	3,448.0
Pay and Allowances of Military Personnel in R&D	240.1
Military Construction	52.2
Defense Agencies	677.2
RDT&E Appropriations	669.8
Pay and Allowances of Military Personnel in R&D	7.3
Military Construction	.2
Departmentwide Funds	1.0
Director of Test and Evaluation, Defense	26.3
Department of Health, Education, and Welfare, Total	2,558.6
Alcohol, Drug Abuse and Mental Health Administration	129.4
Center for Disease Control	40.1
Food and Drug Administration	30.0
Health Resources Administration	29.9
Health Services Administration	14.9
National Institute of Education	88.0
National Institute of Health	2,010.0
Office of Education	77.7
Office of Human Development	63.4
Office of the Assistant Secretary for Education	11.1
Office of the Secretary	29.6
Social and Rehabilitation Service	9.2
Social Security Administration	25.2
Department of Housing and Urban Development	73.8
Department of the Interior, Total	308.1
Bonneville Power Administration	4.7
Bureau of Land Management	1.0
Bureau of Mines	129.1

Bureau of Outdoor Recreation	*
Bureau of Reclamation	8.2
Geological Survey	114.8
National Park Service	9.6
Office of the Secretary	1.5
Office of Water Research and Technology	18.2
United States Fish and Wildlife Service	21.0
Department of Justice, Total	42.9
Bureau of Prisons	1.8
Drug Enforcement Administration	3.6
Federal Bureau of Investigation	.6
Immigration and Naturalization Service	.4
Law Enforcement Assistance Administration	36.6
Department of Labor, Total	34.2
Bureau of Labor Statistics	1.7
Employment and Training Administration	15.8
Employment Standards Administration	5.5
Labor-Management Services Administration	2.8
Occupation Safety and Health Administration	6.3
Office of the Secretary	2.2
Department of State, Total	26.6
Departmental Funds	1.5
Agency for International Development	25.0
Department of Transportation, Total	347.5
Federal Aviation Administration	109.9
Federal Highway Administration	42.8
Federal Railroad Administration	41.8
National Highway Traffic Safety Administration	40.8
Office of the Secretary	29.1
United States Coast Guard	18.5
Urban Mass Transportation Administration	64.6
Department of the Treasury, Total	1.6
Bureau of Engraving and Printing	1.6

Other Agencies

Action	*
Advisory Commission on Intergovernmental Relations	1.4
Civil Aeronautics Board	.5
Civil Service Commission	3.9
Community Services Administration	39.0
Consumer Product Safety Commission	6.4
Energy Research and Development Administration	3,479.5
Environmental Protection Agency	303.0
Federal Communications Commission	1.6
Federal Energy Administration	5.6
Federal Home Loan Bank Board	.8
Federal Trade Commission	1.3
General Services Administration	2.8
Library of Congress	3.4
National Aeronautics and Space Administration	3,676.0
National Science Foundation	679.8
Nuclear Regulatory Commission	106.5
Office of Telecommunications Policy	2.7
Small Business Administration	.6
Smithsonian Institution	31.6
Special Action Office for Drug Abuse Prevention	*
Tennessee Valley Authority	31.0
United States Arms Control and Disarmament Agency	2.3
United States Information Agency	.1
Veterans Administration	105.2

*Indicates amount less than $50,000.

APPENDIX C

AREAS OF FEDERAL RESEARCH AND DEVELOPMENT
[Ref. 20, pp. 1035-44]

AERONAUTICS

Aerodynamics: Operational flight characteristics and problems of fullscale aircraft as they are affected by the dynamics of air.

Aeronautics: Aircraft operations such as takeoff and landing, air traffic, all-weather and night flight, flight safety, and ground safety.

Aircraft: Design, production, and maintenance of aircraft, aircraft components, and aircraft equipment. Includes lighter-than-air craft, gliders, rotating-wing aircraft, and ground effect machines. Structural studies of complete aircraft parts such as airframes, bodies, wings, etc. Stability and control systems, boundry layer control systems, dynamic and static control devices. Aircraft damage assessment and vulnerability studies; effects of gunfire and blast on aircraft and flight equipment.

Aircraft Flight Instrumentation: Instruments necessary for controlling the flight of an aircraft. Includes artificial horizon, airspeed indicator, altimeter, etc.

Air Facilities: Airports, runways, hangars, control towers, ground refueling systems, aircraft handling and maintenance equipment.

AGRICULTURE

Agricultural Chemistry: The application of chemistry to the production and use of crops and livestock; chemurgy, fertilizers, feeds.

Agricultural Economics: Economic conditions, markets, production controls, subsidies, etc. affecting agriculture.

Agricultural Engineering: Design of farm machinery and farm structures. Soil conservation, water conservation, and irrigation. Processing of farm products.

Agronomy and Horticulture: Field crop production, cultivation of orchards, gardens, nurseries, etc. For plant anatomy, physiology, etc.

Animal Husbandry: Production and care of domestic animals, such as bovines, sheep, goats, horses, and swine; domestic animals used as pets. Includes, veterinary medicine.

Forestry: Development, management, and cultivation of forests.

ASTRONOMY AND ASTROPHYSICS

Astronomy: Observation of celestial bodies, their distances, positions, etc.

Astrophysics: Physical and chemical aspects of celestial bodies, their origin and evolution. Includes astronomical spectroscopy and radio astronomy.

Celestial Mechanics: The motions of celestial bodies under the influence of gravity.

ATMOSPHERIC SCIENCES

Atmospheric Physics: Physical and chemical properties of the atmosphere, exclusive of considerations of weather and climate, Aeronomy, aurora and airglow, atmospheric structure, energetic particles, solar-terrestrial relationships, etc.

Meteorology: Weather observation, prediction, and modification, Climatology.

BEHAVIORAL AND SOCIAL SCIENCES

Administration and Management: Accounting, planning, budgeting, operations, public relations, production planning, organization coordination, etc.

Documentation and Information Technology: Library science: acquisition, cataloging, indexing, abstracting, bibliography. Information storage and retrieval systems.

Economics: Econometrics, economic history, economic theory, banking and finance, international economic relations, trade and commerce.

History, Law, and Political Science: Theory and practice of government, international relations, politics, law, etc.

Human Factors Engineering: Design of equipment with emphasis on optimum utilization by humans. Habitability of work and living space.

Humanities: Philosophy, literature, art, music, drama, etc.

Linguistics: Study of languages, including phonology, morphology, syntax, and semantics. Mathematical linguistics. Machine translation.

Man-Machine Relations: Interaction of man and equipment in terms of subsystem and system performance requirements and evaluation. Encompasses manual controls, information displays. Information processing, tactical kinethesis and other human sensory modalities involved in operation of equipment and understanding of personnel subsystems.

Personnel Selection, Training, and Evaluation: Recruitment, selection, training, and utilization of personnel. Industrial relations, wages, benefits. Education, teaching aids, teaching methods. Job analysis, career guidance.

Psychology (Individual and Group Behavior): Mental processes and phenomena such as perception, learning motivation, intelligence, attitudes, group dynamics, etc. Experimental psychology, including animal behavior; physiological psychology; developmental psychology; social psychology; clinical psychology; educational psychology; military psychology; and parapsychology.

Sociology: Social relations, the functioning of human society, ethnology, criminology, etc.

BIOLOGICAL AND MEDICAL SCIENCES

Biochemistry: Studies of the chemical processes which take place in biological systems. Identification of biochemical substances and the methods used for biochemical assay and analysis.

Bioengineering: Establishment of requirements for, and development of, bioinstrumentation and equipment needed by man in operation of man-machine systems. Includes instrumentation for psychophysiological monitoring and biomedical information handling. Compact, lightweight transducers and transmitter equipment introducing minimum constraint of subject. Man's requirements for displays and controls. Use of body potentials as intrinsic power supplies.

Biology: Biological topics not included in other Groups, e.g., botany, zoology, genetic, etc. Animal anatomy, physiology, and pathology. Care and breeding of laboratory animals.

Bionics: Study of biological processes in order to develop engineering systems.

Clinical Medicine: General medicine, medical specialties, and paramedical sciences. Internal medicine, including preventive medicine; pediatrics and geriatrics; dermatology, ophthalmology; psychiatry; dentistry. Includes nursing, first aid, medical technology, physical therapy, and prosthesis.

Environmental Biology: External influences on the biological processes of organism. Ecology, pesticides, insect vectors, pest control, natural noxious agents, etc.

Escape, Rescue, and Survival: Methods and equipment for escape from disabled aircraft, submarines, etc. Rescue equipment, signals, flotation devices, survival kits.

Food: Processing, packaging, storage, preparation, and dispensing of food. Kitchen equipment.

Hygiene and Sanitation: Personal hygiene.

Industrial (Occupation) Medicine: Interaction of man and industrial environment. Noise, physical trauma, etc.

Life Support: Equipment and techniques for sustaining life in environments where normal respiration is not possible. Systems which provide, as a minimum, respiratory support. Includes closed ecological systems, space suits, diving gear, oxygen masks, etc.

Medical and Hospital Equipment and Supplies: Equipment and supplies for laboratory and field use.

Microbiology: Studies of microscopic plants and animals.

Personnel Selection and Maintenance (Medical): Physical standards, examinations, anthropometrics, physical fitness.

Pharmacology: The synthesis, composition, properties, and physiological effects of drugs. Includes psychopharmacology.

Physiology: Organic processes and phenomena of humans, e.g., growth, aging, metabolism, biological rhythm, healing and repair, sensation, etc. Human anatomy.

Protective Equipment: Equipment providing protection against such environmental elements as heat, cold, noise, machinery, etc.

Radiobiology: Radiation biology. Interaction of biological systems with electromagnetic and particle radiation. Dosimetry, health physics, radiation injury. Prophylaxis and therapy of nuclear radiation sickness and injury.

Stress Physiology: Effects of extreme environments or unusual stimulation on biological processes. Physiological effects of motion, gravity, sound, light, heat, magnetism, sensory deprivation, fatigue, etc.

Toxicology: Detection, neutralization, decontamination, physiological effects, etc. of poisonous substances.

Weapon Effects: Wounds, injuries, or other medical conditions directly resulting from weapons.

CHEMISTRY

Chemical Engineering: Techniques, processes, unit operations, apparatus, and plant equipment that apply to chemical manufacturing, processing, transportation, and storage.

Inorganic Chemistry: Synthesis, properties, and reactions of inorganic compounds; studies of the elements; inorganic quantitative and qualitative analysis.

Organic Chemistry: Synthesis, properties, and reactions of organic compounds; organic quantitative and qualitative analysis.

Physical Chemistry: Physical aspects and theoretical interpretations of chemical systems. Colloid chemistry, catalysis, solutions, chemical equilibria and reaction kinetics, surface chemistry, chemical thermodynamics and thermochemistry, etc. Physical methods of analysis not applied exclusively to either organic or inorganic chemical substances. Atomic and molecular structure and spectra; spectroscopic analysis for the fundamental understanding of chemical bonding, nuclear motions, etc. Nuclear magnetic resonance spectroscopy and electron paramagnetic resonance spectroscopy.

Radio and Radiation Chemistry: Chemistry of the effects of electromagnetic and particle radiation on matter. Chemistry of radioactive substances. Tracer studies. Includes photochemistry.

EARTH SCIENCES AND OCEANOGRAPHY

Biological Oceanography: Marine plant and animal life as it relates to its environment.

Cartography: Mapping, photogrammetry, terrain models, etc.

Dynamic Oceanography: Ocean waves, currents, tides, ocean-air interactions, etc.

Geochemistry: Chemical composition of the earth's crust.

Geodesy: Geodetic surveying. Determination of position of points on the earth's surface. Shape and size of the earth. Variations of terrestrial gravity.

Geography: Description of the physical features of the earth, the distribution of plants and animals. Includes political, economic, and commercial geography.

Geology and Mineraology: Structure, properties, and classification of rocks, rock formations, and rock constituents. Mineralogy, paleontology, stratigraphy.

Hydrology and Limnology: Properties, distribution, and circulation of water, including its surface and underground occurrence. Physical, chemical, and biological conditions in fresh water bodies.

Mining and Engineering: Location and evaluation of mineral deposits. Layout and equipment of mines. Mining operations.

Physical Oceanography: Physical and chemical properties of ocean water. Topography and composition of the ocean bottom.

Seismology: Detection, measurement, and recording of seismic phenomena.

Snow, Ice, and Permafrost: Physical characteristics of snow, ice and permanently frozen soil.

Soil Mechanics: Physical properties and engineering aspects of soils.

Terrestrial Magnetism: Geomagnetic variations, field theory, magnetic moments, etc.

ELECTRONICS AND ELECTRICAL ENGINEERING

Components: Design and development of basic electrical and electronic components such as electron tubes, semiconductor devices, switches, connectors, etc.

Computers: Design, development, and application of electronic computers and peripheral equipment. Includes analog, digital analog-digital, special-purpose, and general purpose computers; computer accessories, supplies, and installation; computer software such as programs, programming languages, program generators, compiliers, executive routines, and system evaluation.

Electronic and Electrical Engineering: Electronic systems, except those included in Navigation, Communications, Detection, and Countermeasures. Electrical systems.

Information Theory: Representation, uncertainty, noise, information content, information entropy, coding theory.

Subsystems: Electrical and electronic devices which are composed of components, but which require other such devices to form complete systems. Includes amplifiers, antennas, etc.

Telemetry: Techniques and equipment, including transmitters, receivers, antennas, etc.

ENERGY CONVERSION (NON-PROPULSIVE)

Conversion Techniques: Techniques and devices for the conversion of one form of energy to a form of non-electrical energy, but which do not primarily involve energy storage.

Power Sources: Devices which supply electric power by energy conversion processes which do not primarily involve energy storage. Includes generators, converters, fuel cells, etc.

Energy Storage: Techniques and devices for the storage and subsequent use of energy. Includes electrical batteries and battery components.

MATERIALS

Adhesives and Seals: Adhesives, glues, binders, etc. for all types of materials. Sealants, seals, and gaskets.

Ceramics, Refractories, and Glasses: Ceramic materials, including glasses, brick, porcelain, tiles, etc. Non-metallic refractory materials. Cermets.

Coatings, Colorants, and Finishes: Paints, paint primers, varnishes. Plastic, rubber, ceramic, and metal coatings. Uses of dyes and pigments.

Composite Materials: Materials composed of two or more physically distinct constitutents.

Fibers and Textiles: Natural and synthetic fibers, threads, yarns, and textiles.

Metallurgy and Metallography: Refining and production of metals and alloys. Microstructure, physical and mechanical properties, corrosion studies, etc. Heat-resistant metals and alloys. Includes extractive and physical metallurgy.

Miscellaneous Materials: Materials not included in another Group, including leather, fur, and other animal products. Refrigerants, straw, waxes, etc.

Oils, Lubricants, and Hydraulic Fluids: Properties, performance, and production of all types of oils, lubricants, and hydraulic fluids.

Plastics: Properties, performance, and production of all types of plastics and resins, including reinforced plastics and laminates.

Rubbers: Production, performance, and properties of natural and synthetic rubber and rubber products. Elastomers.

Solvents, Cleaners and Abrasives: Cleaning compositions, solvents, detergents, soaps, abrasives, etc.

Wood and Paper Products: Wood, wood products, paper, cardboard, etc.

MATHEMATICAL SCIENCES

Mathematics and Statistics: Mathematics and statistics research.

Operations Research: Theoretical operations research.

MECHANICAL, INDUSTRIAL, CIVIL, AND MARINE ENGINEERING

Air Conditioning, Heating, Lighting, and Ventilating: Air conditioning systems, refrigeration systems, cold storage systems. Heating systems, heat pumps, boilers, furnaces, radiators, condensers. Lighting systems.

Civil Engineering: Water supply systems: well drilling, water collection, storage, treatment, distribution. Sanitary engineering: waste and sewage disposal, air and water pollution control. Flood control. Highway and traffic engineering. Urban planning and renewal.

Construction Equipment, Materials and Supplies: Excavation and earth moving equipment, hoisting and conveying equipment, construction equipment. Building materials and supplies.

Containers and Packaging: Design, production, performance, and testing of containers. Packaging methods. Storage tanks and accessories.

Couplings, Fasteners, and Joints: Design, performance, and testing of bolts, screws, studs, rivets, hooks, couplings, and fittings. Bonded, soldered, and welded joints, etc.

Ground Transportation Equipment: Design, operation, performance, and maintenance of amphibious vehicles, cargo vehicles, passenger vehicles, automotive parts and equipment, and railroad equipment.

Hydraulic and Pneumatic Equipment: Design, production, performance, and testing of hydraulic and pneumatic systems. Accumulators, distribution equipment, actuators, controls, and components.

Industrial Processes: Production control, quality control, plant design, inspection. Fabrication cleaning and finishing, etc. of industrial materials. Includes fabrication metallurgy: casting, forging, drawing, electroforming, extrusion, machining, rolling, stamping, spinning, welding.

Machinery and Tools: Machines and machine elements, including bearings, clutches, drives, gears, cam, springs, etc. Metalworking tools, woodworking tools, dies, jigs, etc.

Marine Engineering: Design, construction, maintenance, salvage, operation, and performance of all types of ships, boats, and marine equipment.

Submarine Engineering: Design, construction, maintenance, salvage, operation, and performance of submarines and submarine equipment.

Pumps, Filters, Pipes, Tubing and Valves: Design, construction, operation and performance of all types of pumps, filters, pipes and pipe fittings and valves.

Safety Engineering: Accident prevention, safety devices, fire-fighting equipment, fire-detection equipment.

Structural Engineering: Design and construction of structures such as buildings, bridges, dams, etc.

METHODS AND EQUIPMENT

Cost Effectiveness: Examination and selection of equipment, materials, personnel, etc. for optimum performance of given tasks. Cost-benefit analysis, tradeoff factors, etc.

Laboratories, Test Facilities, and Test Equipment: Laboratory and test facility design and operation. Measuring, testing, and simulation devices with apparent application in more than one Group.

Recording Devices: Techniques and devices for electrical recording. Includes disk, magnetic, electrostatic, etc.

Reliability: Determination of the probability of satisfactory performance of components and equipment. Prevention and correction of malfunctions.

Reprography: Photographic techniques, equipment, and materials. Reproduction techniques. Printing and graphic arts.

MILITARY SCIENCES

Antisubmarine Warfare: Operations conducted against submarines.

Chemical, Biological, and Radiological Warfare: Development and utilization of lethal and non-lethal chemical agents, biological agents, and radiological weapons. Detection, decontamination, protective equipment, etc. CBR ordnance items, such as bombs, projectiles, and rockets.

Defense: Active and passive systems for military and civil defense. Antiaircraft and antisatellite defense systems.

Antimissile Defense: Techniques and equipment for the interception and destruction of guided missiles.

Intelligence: Techniques for collecting, evaluating, and disseminating information concerning foreign nations needed for purposes of national security.

Logistics: Procurement, storage, distribution, and reclamation of equipment and supplies. Design and testing of personal equipment, such as clothing, field gear, etc. Transportation. Industrial mobilization.

Nuclear Warfare: Development and utilization of nuclear weapons. Studies of the physics and physiological effects of nuclear weapons.

Operations, Strategy, and Tactics: Joint and combined operations. Campaigns, battles, invasions, theater operations, etc. Methods of attack and support. Types of warfare.

MISSILE TECHNOLOGY

Missile Launching and Ground Support: Missile handling and launching, including transportation; storage; preparation for launching; surface, aircraft, or underwater launching. Launching equipment, checkout equipment, and ground support equipment.

Missile Trajectories: Determination, analysis, and processing of missile trajectory data. Flight path analysis, impact prediction, etc. Operational aerodynamic studies, including reentry.

Missile Warheads and Fuzes: Design and performance of all warhead types, including explosive, chemical, biological, and nuclear. Missile fuzes of all types.

Missiles: General missile theory, design, construction, performance, and components. Damage assessment and vulnerability studies.

Air- and Space-Launched Missiles: Theory, design, construction, performance, and components. Damage assessment and vulnerability studies.

Surface-Launched Missiles: Theory, design, construction, performance, and components. Damage assessment and vulnerability studies.

Underwater-Launched Missiles: Theory, design, construction, performance, and components. Damage assessment and vulnerability studies.

NAVIGATION, COMMUNICATIONS, DETECTION AND COUNTERMEASURES

Acoustic Detection: Detection by means of acoustic waves, including ultrasonic and infrasonic radiation.

Communications: Communications by wire or electromagnetic waves other than radio waves.

Radio Communications: Communications by radio waves.

Direction Finding: Determination of the direction of arrival of signals.

Electromagnetic and Acoustic Countermeasures: Interception, jamming and antijamming, and deception of acoustic and electromagnetic signals.

Infrared and Ultraviolet Detection: Detection by measurement of infrared or ultraviolet radiation.

Magnetic Detection: Detection by measurement of a magnetic field.

Navigation and Guidance: Techniques for navigation and guidance. Includes air traffic control systems, controlled-approach systems, and instrument landing systems.

Optical Detection: Detection by means of light. Includes such optical instruments as binoculars and periscopes.

Radar Detection: Detection by means of transmitted and reflected radiofrequency waves.

Seismic Detection: Detection by measurement of seismic waves.

NUCLEAR SCIENCE AND TECHNOLOGY

Fusion Devices (Thermonuclear): Theory, design, construction, and operation of devices for producing controlled thermonuclear fusion reactions.

Isotopes: Separation or concentration of isotopes. Industrial and medical applications.

Nuclear Explosions: Explosion effects such as shock waves and earth movement. Testing of nuclear devices. Peaceful applications, such as Plowshare.

Nuclear Instrumentation: Radiation detection devices and associated equipment.

Nuclear Power Plants: Integrated assemblage, including reactor and turbogenerator equipment, plus control and regulatory devices. Includes mobile as well as stationary power plants.

Radiation Shielding and Protection: Shielding design, isodose plots, materials transmission and absorption studies, safety devices, decontamination, etc.

Radioactive Wastes and Fission Products: Separation, processing, handling, storage, and disposal. Fission product utilization.

Radioactivity: Radioactive decay, natural and induced radioactivity, interaction of charged particles and radiation with matter, radioactive fallout.

Reactor Engineering and Operations: Engineering related directly to the design or operation of a specific reactor or reactor type.

Reactor Materials: Production, testing, or reclamation of fuel materials, coolants, moderators, control materials, structural materials, and shielding materials. Includes fabricated elements or assemblies and specific configurations.

Reactor Physics: Reactor kinetics, reactor theory, criticality and neutron thermalization, scattering, slowing down economy, etc. Includes the use of reactor simulators or computers.

Reactors (Power): Design, construction, operation, etc., of reactors used as energy sources for electric power generation.

Reactors (Non-Power): Reactors designed and built for purposes other than for electric power of propulsion. Includes production research and training, test, and process heat types.

SNAP Technology: Systems for Nuclear Auxiliary Power, both isotopic and reactor.

ORDNANCE

Ammunition, Explosives, and Pyrotechnics: Projectiles, fuzes, demolition explosives, detonators, grenades, land mines, high explosives, primers, powder propellants, ammunition shaped charges, flame throwers, ammunition handling equipment, etc. Production, performance, stability in storage, etc. of incendiaries, pyrotechnics, screening agents and smokes, etc.

Bombs: High-explosive, fragmentation, anti-personnel, armor-piercing, general-purpose, etc. Bomb handling equipment.

Combat Vehicles: Armored wheeled and track-laying vehicles for both cargo and personnel. Heavy, light, and medium tanks. Tank chassis used as gun carriers, their components and accessories.

Explosions, Ballistics, and Armor: Explosion effects such as blast, heat, earth movement, etc. Ballistics. Armor plate, body armor, etc.

Fire Control and Bombing Systems: Computers, sights, directors, range finders, gun-laying and bombing radar systems, bomb releases, and other devices used to direct the firing of a weapon.

Guns: Small arms, automatic weapons, recoilless weapons, mortars, artillery and naval guns, their components, accessories, and interior ballistics. Gun carriages, gun mounts, remote control equipment, etc.

Rockets: Rocket-propelled weapons, including aircraft, large caliber, and shoulder-fired rockets. Launching devices.

Underwater Ordnance: Torpedoes, submarine mines, depth charges, hydrobombs, etc. Launching devices and countermeasures.

PHYSICS

Acoustics: Generation and propagation of acoustic waves, including ultrasonic and infrasonic radiation.

Crystallography: Structure and properties of crystalline forms.

Electricity and Magnetism: Theory of electrical and magnetic phenomena.

Fluid Mechanics: Theoretical and experimental studies of the dynamics and statics of fluids, including aerodynamics and hydrodynamics.

Masers and Lasers: Devices which amplify electromagnetic waves by stimulated emission of radiation. Includes irasers, uvasers, etc.

Optics: Generation and propagation of electromagnetic waves in the infrared, visible, and ultraviolet regions of the spectrum. Techniques and design of optical equipment for mass spectroscopy.

Particle Accelerators: Design and operation of betatrons, cyclotrons, synchrotrons, etc.

Particle Physics: Properties and reactions of elementary particles. Nuclear reactions. Gamma rays, x rays.

Plasma Physics: Properties and actions of plasmas, including magnetohydrodynamics, pinch effect, plasma oscillations, plasma jets, etc.

Quantum Theory: Relativistic and nonrelativistic quantum theory, relativity theory, quantum mechanics and quantum statistics.

Solid Mechanics: Dynamics and statics of solid bodies. Structural mechanics, kinetics, kinematics, equilibria, stress analysis, buckling, elasticity, plasticity, vibrations, shock and vibration, etc.

Solid State Physics: Structure and properties of solids. Properties of solids at cryogenic temperatures. Includes fundamental research and theoretical studies of semiconductors.

Thermodynamics: Thermodynamic theory; equations of state, free energy, enthalpy, entropy, thermodynamic cycles, etc. Heat transfer, including methods for determining thermal radiation properties of materials. Low-temperature phenomena.

Wave propagation: Propagation of radiofrequency waves. Includes microwave optics.

PROPULSION AND FUELS

Air Breathing Engines: Advanced engines which use ingested air to oxidize their fuel, e.g., the liquid air cycle engine (LACE).

Combustion and Ignition: Combustion and flame studies. Ignition and ignition systems.

Electric Propulsion: All types of engines deriving power from free ions or electrons. Ion, plasma, and arc-jet engines.

Fuels: Production, performance, storage, etc. of all types of fuels except those used in rocket engines.

Jet and Gas Turbine Engines: All types of jet and gas turbine engines, including hydroduct, turboprop, etc.

Nuclear Propulsion: Nuclear devices for marine, ground, air, and space propulsion.

Reciprocating Engines: Reciprocating Engines of various configurations for all types of propulsion.

Rocket Motors and Engines: General studies of rocket motors and propulsion hardware. Gaseous, thixotropic, and hybrid rocket motors.

Liquid Rocket Motors: Studies of liquid rocket motors and propulsion hardware.

Solid Rocket Motors: Studies of solid rocket motors and propulsion hardware.

Rocket Propellants: Chemical rocket propellants and propellant combinations other than all-liquid or all-solid propellants. Includes production, handling, performance, etc.

Liquid Rocket Propellants: Production, handling, performance, etc. of all-liquid rocket propellants, including fuels, oxidizers, etc.

Solid Rocket Propellants: Production, handling, performance, etc. of all-solid rocket propellants, including fuels, oxidizers, additives, binders, etc.

SPACE TECHNOLOGY

Astronautics: Orbital rendezvous, space exploration, operations in space, spacecraft operating problems, etc.

Spacecraft: Design and construction of spacecraft, including satellites, space probes, space capsules, spaceships, space stations, aerospace planes, and their components. Spacecraft damage assessment and vulnerability studies.

Spacecraft Trajectories and Reentry: Determination, analysis, processing, etc. of spacecraft trajectory data. Orbital calculations, flight path analysis, reentry, space mechanics, etc.

Spacecraft Launch Vehicles and Ground Support: Handling and launching, including transportation, storage, preparation for launching, and countdown. Launching equipment, checkout equipment, and ground support equipment.

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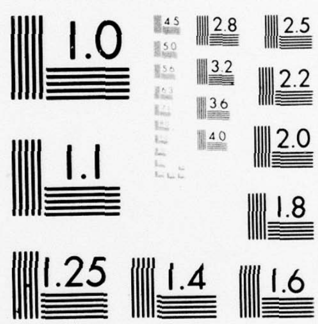

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